CLAIMS

We claim:

1. A method of forming a planarized final copper structure, comprising the steps of:

providing a structure having a patterned dielectric layer formed thereover; the patterned dielectric layer having an opening formed therein;

forming a barrier layer over the patterned dielectric layer and lining the opening;

forming an initial planarized copper structure within the barrier layer lined opening, planar with the barrier layer overlying the patterned dielectric layer;

recessing the initial planarized copper structure below the barrier layer overlying the patterned dielectric layer a distance to form a recessed copper structure;

removing any copper oxide formed upon the recessed copper structure;

forming a conductor film over the recessed, copper oxide-free initial copper structure and the barrier layer;

removing the excess of the conductor film over the barrier layer and the excess of the barrier layer overlying the patterned dielectric layer by a planarization process to form the planarized final copper structure; the planarized final copper structure comprising: the lower recessed, copper oxide-free initial copper structure; and an overlying planarized conductor film.

2. The method of claim 1, wherein the opening is a damascene opening or a dual damascene opening.

3. The method of claim 1, wherein the patterned dielectric layer is comprised of a material selected from the group consisting of: silicon oxide; FSG, a spin-on dielectric material, Black Diamond™ and nanoporous silica; the barrier layer is comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN; and the conductor film is comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN.

4. The method of claim 1, wherein the patterned dielectric layer is comprised of silicon oxide; the barrier layer is comprised of TaN; and the conductor film is comprised of TaN.

5. The method of claim 1, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 180 to 500Å.

6. The method of claim 1, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 250 to 210Å.

7. The method of claim 1, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is about 300Å.

8. The method of claim 1, wherein the barrier layer has a thickness of from about 50 to 1000Å.

9. The method of claim 1, wherein the barrier layer has a thickness of from about 50 to 300Å.

10. The method of claim 1, wherein the initial planarized copper structure is recessed using a selective etch process.

11. The method of claim 1, wherein the initial planarized copper structure is recessed using a selective etch process employing an aqueous solution selected from the group consisting of NH_3/H_2O; $NH_3/H_2O_2/H_2O$; HNO_4/H_2O; HCl/H_2O and H_2SO_4/H_2O.

12. The method of claim 1, wherein the initial planarized copper structure is recessed using a selective etch process employing an $NH_3/H_2O_2/H_2O$ aqueous solution.

13. The method of claim 1, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment.

14. The method of claim 1, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent.

15. The method of claim 1, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3; H_2 and N_2.

16. The method of claim 1, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3 and H_2.

17. The method of claim 1, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing an NH_3 plasma copper reducing agent.

18. The method of claim 1, wherein the conductor film formation and the copper oxide removal are performed in situ in the same physical vapor deposition tool.

19. A method of forming a planarized final copper structure, comprising the steps of:

providing a structure having a patterned dielectric layer formed thereover; the patterned dielectric layer having an opening formed therein; the patterned

dielectric layer being comprised of a material selected from the group consisting of: silicon oxide; FSG, a spin-on dielectric material, Black Diamond™ and nanoporous silica;

forming a barrier layer over the patterned dielectric layer and lining the opening; the barrier layer being comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN;

forming an initial planarized copper structure within the barrier layer lined opening, planar with the barrier layer overlying the patterned dielectric layer;

recessing the initial planarized copper structure below the barrier layer overlying the patterned dielectric layer a distance to form a recessed copper structure;

removing any copper oxide formed upon the recessed copper structure;

forming a conductor film over the recessed, copper oxide-free initial copper structure and the barrier layer; the conductor film being comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN;

removing the excess of the conductor film over the barrier layer and the excess of the barrier layer overlying the patterned dielectric layer by a planarization process to form the planarized final copper structure; the planarized final copper structure comprising: the lower recessed, copper oxide-free initial copper structure; and an overlying planarized conductor film.

20. The method of claim 19, wherein the opening is a damascene opening or a dual damascene opening.

21. The method of claim 19, wherein the patterned dielectric layer is comprised of silicon oxide; the barrier layer is comprised of TaN; and the conductor film is comprised of TaN.

22. The method of claim 19, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 180 to 500Å.

23. The method of claim 19, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 250 to 350Å.

24. The method of claim 19, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is about 300Å.

25. The method of claim 19, wherein the barrier layer has a thickness of from about 50 to 1000Å.

26. The method of claim 19, wherein the barrier layer has a thickness of from about 50 to 300Å.

27. The method of claim 19, wherein the initial planarized copper structure is recessed using a selective etch process.

28. The method of claim 19, wherein the initial planarized copper structure is recessed using a selective etch process employing an aqueous solution selected from the group consisting of NH_3/H_2O; $NH_3/H_2O_2/H_2O$; HNO_4/H_2O; HCl/H_2O and H_2SO_4/H_2O.

29. The method of claim 19, wherein the initial planarized copper structure is recessed using a selective etch process employing an $NH_3/H_2O_2/H_2O$ aqueous solution.

30. The method of claim 19, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment.

31. The method of claim 19, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent.

32. The method of claim 19, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3; H_2; and N_2.

33. The method of claim 19, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3 and H_2.

34. The method of claim 19, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing an NH_3 plasma copper reducing agent.

35. The method of claim 19, wherein the conductor film formation and the copper oxide removal are performed in situ in the same physical vapor deposition tool.

36. A planarized final copper structure, comprising:

a lower, recessed copper structure disposed within a patterned dielectric layer opening; the patterned dielectric layer having an upper surface and the lower, recessed copper structure recessed from about 180 to 500Å below the upper surface of the patterned dielectric layer; the lower, recessed copper structure having a copper oxide-free upper surface; and

an upper, planarized conductor film disposed upon the copper oxide-free upper surface of the lower, recessed copper structure to isolate the copper oxide-free upper surface from the ambient atmosphere; the upper, planarized conductor film having an upper surface that is substantially flush with the upper surface of the patterned dielectric layer.

37. The method of claim 36, wherein a barrier layer is interposed between the patterned dielectric layer opening and: the lower, recessed copper structure; and the upper, planarized conductor film.

38. The method of claim 36, wherein a barrier layer is interposed between the patterned dielectric layer opening and: the lower, recessed copper structure; and the upper, planarized conductor film; the barrier layer having a thickness of from about 50 to 1000Å.

39. The method of claim 36, wherein a barrier layer is interposed between the patterned dielectric layer opening and: the lower, recessed copper structure; and the upper, planarized conductor film; the barrier layer having a thickness of from about 50 to 300Å.

40. The method of claim 36, wherein a barrier layer is interposed between the patterned dielectric layer opening and: the lower, recessed copper structure; and the upper, planarized conductor film; the barrier layer being comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN; the patterned dielectric layer being comprised of a material selected from the group consisting of: silicon oxide; FSG, a spin-on dielectric material, Black Diamond™ and nanoporous silica; and the planarized conductor film being comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN.

41. The method of claim 36, wherein a barrier layer is interposed between the patterned dielectric layer opening and: the lower, recessed copper structure; and the upper, planarized conductor film; the barrier layer being comprised of TaN; the patterned dielectric layer being comprised of silicon oxide; and the planarized conductor film being comprised of TaN.

42. The method of claim 36, wherein the patterned dielectric layer is comprised of a material selected from the group consisting of: silicon oxide; FSG, a spin-on dielectric material, Black Diamond™ and nanoporous silica; and the planarized conductor film is comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN.

43. The method of claim 36, wherein the patterned dielectric layer is comprised of silicon oxide; and the planarized conductor film is comprised of TaN.

44. The method of claim 36, wherein the lower, recessed copper structure recessed from about 250 to 350Å below the upper surface of the patterned dielectric layer.

45. The method of claim 36, wherein the lower, recessed copper structure recessed about 300Å below the upper surface of the patterned dielectric layer.

46. The method of claim 36, wherein the opening is a dual damascene opening or a damascene opening.

47. A method of forming a planarized final copper structure, comprising the steps of:

providing a structure having a patterned dielectric layer formed thereover; the patterned dielectric layer having an opening formed therein;

forming a barrier layer over the patterned dielectric layer and lining the opening; the barrier layer being comprised of a material selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta; TiSiN and TaSiN;

forming an initial planarized copper structure within the barrier layer lined opening, planar with the barrier layer overlying the patterned dielectric layer;

recessing the initial planarized copper structure below the barrier layer overlying the patterned dielectric layer a distance to form a recessed copper structure; the initial planarized copper structure being recessed using a selective etch process employing an aqueous solution selected from the group consisting of:

i) NH_3/H_2O;

ii) $NH_3/H_2O_2/H_2O$;

iii) HNO_4/H_2O;

iv) HCl/H_2O; and

v) H_2SO_4/H_2O;

removing any copper oxide formed upon the recessed copper structure using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3; H_2 and N_2;

forming a conductor film over the recessed, copper oxide-free initial copper structure and the barrier layer; the conductor film being comprised of a material

selected from the group consisting of: TaN; TiN; WN; TaN + Co; Ta, TiSiN and TaSiN;

removing the excess of the conductor film over the barrier layer and the excess of the barrier layer overlying the patterned dielectric layer by a planarization process to form the planarized final copper structure; the planarized final copper structure comprising: the lower recessed, copper oxide-free initial copper structure; and an overlying planarized conductor film.

48. The method of claim 47, wherein the opening is a damascene opening or a dual damascene opening.

49. The method of claim 47, wherein the patterned dielectric layer is comprised of a material selected from the group consisting of: silicon oxide; FSG, a spin-on dielectric material, Black Diamond™ and nanoporous silica.

50. The method of claim 47, wherein the patterned dielectric layer is comprised of silicon oxide; the barrier layer is comprised of TaN; and the conductor film is comprised of TaN.

51. The method of claim 47, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 180 to 500Å.

52. The method of claim 47, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is from about 250 to 350Å.

53. The method of claim 47, wherein the distance the initial planarized copper structure is recessed below the barrier layer overlying the patterned dielectric layer is about 300Å.

54. The method of claim 47, wherein the barrier layer has a thickness of from about 50 to 1000Å.

55. The method of claim 47, wherein the barrier layer has a thickness of from about 50 to 300Å.

56. The method of claim 47, wherein the initial planarized copper structure is recessed using a selective etch process.

57. The method of claim 47, wherein the initial planarized copper structure is recessed using a selective etch process employing an $NH_3/H_2O_2/H_2O$ aqueous solution.

58. The method of claim 47, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment.

59. The method of claim 47, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent.

60. The method of claim 47, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing a plasma copper reducing agent selected from the group consisting of: NH_3 and H_2.

61. The method of claim 47, wherein the copper oxide formed upon the recessed copper structure is removed using a reducing treatment employing an NH_3 plasma copper reducing agent.

62. The method of claim 47, wherein the conductor film formation and the copper oxide removal are performed in situ in the same physical vapor deposition tool.